AN X-RAY STUDY OF G272.2-3.2 – A NEWLY DISCOVERED SUPERNOVA REMNANT

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The subject grant is for work on a study of X-ray emission from galactic supernova remnants (SNRs). The purpose of the study is to 1)determine whether the emission from the remnants is thermal or nonthermal; 2)compare the observed temperature and morphological characteristics with models for SNR evolution; and 3)search for any evidence of pulsars associated with the SNRs.

We obtained ASCA observations of the remnants MSH 11-61A, W28, CTA 1, 3C58, and G272.2–3.2. The analysis of these data is partially complete. Spectra from MSH 11-61A and W28 reveal that the emission is clearly thermal in nature for both sources. Comparisons of the spectral and morphological characteristics with models for SNR evolution in a cloudy interstellar medium (ISM) and for models of radiative-phase remnants are in progress. Preliminary results were recently reported at the 188th meeting of the American Astronomical Society. A copy of the abstract in attached to this report.

The ASCA observation of CTA 1 covered only the central regions of this remnant. These data have been analyzed and the central spectrum is clearly nonthermal suggesting the presence of a central pulsar. These results were also presented at the AAS meeting, and a paper summarizing the results is in progress. A proposal for ASCA followup observations of the outer regions of the remnant has been recently submitted.

The analysis of the 3C58 data has been somewhat delayed because the data provided by the ASCA GOF was not carried out in the requested timing mode. Calibration data containing the proper mode has been recently made available. Initial investigations of the spectral characteristics show that the power law spectral index increases with radius. Initial timing studies using only medium time resolution data reveal no significant evidence of pulsations, though more meaningful limits (or detection) await the analysis of the higher time resolution data. These initial results were reported at the recent ASCA Symposium. A copy of the preprint, to be published in "X-ray Imaging and Spectroscopy of Cosmic Hot

Plasmas" is attached to this report.

Preliminary work has begun on the analysis of data from G272.2–3.2. The spectral analysis clearly reveals thermal emission from this remnant. Our efforts in the near term will be concentrated on a determination of the ionization state and composition of the hot gas in an effort to determine whether the emission is characteristic of a young or old remnant.

the large luminosity separation between these post-EHB stars and the EHB is not predicted by canonical models of HB and post-HB evolution. We show that this luminosity separation and the numbers of post-EHB stars can be explained by noncanonical models whose envelopes have been enriched in helium by internal mixing during the preceding red-giant-branch phase.

28.03

ROSAT Observations of Classical Novae

M. Orio (U Wisconsin & Torino), H. Ogelman (U Wisconsin)

We observed a number of classical and recurrent novae in the Galaxy and LMC with the ROSAT X-ray telescope and searched the archival data for other serendipitous observations. Preliminary partial results show that only 10 out of 60 observed objects were bright enough in X-rays to be detected with ROSAT, either in outburst or at quiescence. We review the mechansims that cause X-ray emission from classical novae and derive upper limits on the mass accretion rate of quiescent novae and on the length of the constant bolometric luminosity phase after the outburst.

28.04D

An X-ray Study of Composite Supernova Remnants

Jeonghee Rho (UMCP and NASA/GSFC)

Composite supernova remnants (SNRs) appear center-filled in X-rays and have a shell-like radio morphology. I have used ROSAT and ASCA data to study a sample of ~20 composite SNR, six of these in detail, to understand the origin of centrally enhanced X-ray emission. Seven of the sample remnants (W44, W28, 3C400.2 Kes 27, MSH 11-61A, 3C391, and CTB 1) were found to be clearly mixed morphology (M-type) composites, and their central surface brightness is a factor of 2-5 times that at the edge. Despite their X-ray morphological similarity to plerions, the dominant X-ray spectral component is thermal (e.g. ASCA spectra show line emission). Another six remnants (e.g. W63, and HB21) are possible M-type composites. The remnants IC443, Kes 79 and HB 3 are similar to these composites; however, other physical processes are required to explain their properties. MSH 11-54 is definitely not a M-type composite, because the emission is enhanced by the ejecta from the progenitor.

For M-type composites, the temperature of the X-ray emitting plasma is largely uniform across the remnant, and the pressure and density either do not vary across the remnant, or slightly increase radially inwards, contrary to the classical Sedov solution. I have examined several hypotheses which purport to explain the origin of the X-ray emission: "fossil" radiation from the hot interior, a reverse shock, a stellar wind, large scale ISM structures, a reflected shock, and evaporating clouds. The hypothesis invoking evaporation of clouds in the SNR interior (McKee 1981; White & Long 1991) appears to be most consistent with the X-ray data, e.g. in the temperature, density, and pressure profiles. The clouds within a multi-phase interstellar medium are the source of the X-ray centrally peaked morphology. A simulation of the enhanced X-ray emission due to evaporation around a cloud is presented for the cases of both classical and saturated conduction based on Cowie & McKee (1977). For the classical conduction, the emission is enhanced by less than a factor of 3 for $T < 10^7$ K. However, when the conduction becomes saturated, which is often the case around evaporating clumps, the X-ray emission can be enhanced by a factor of 3-20 and the enhancement appears smooth around the clouds.

28.05

An Investigation of Supernova Remnants With Centrally Bright X-Ray Morphology

P.Slane (SAO)

X-ray observations of supernova remnants have revealed a distinct class of objects whose X-ray morphology is in complete contrast with that expected from standard evolutionary scenarios. While the radio emission exhibits the expected limb-brightened emission profiles, the X-ray emission is centrally peaked with little or no evidence of a shell. Unlike the Crab-like remnants, however, the X-ray emission from these remnants is thermal in nature, thus ruling our a central plerion driven by a pulsar as the explanation for the central brightness. Here we present a joint spatial and spectral study of several remnants from this class, including W28 and MSH 11-61A, using data from the ROSAT and ASCA observatories. We compare the observed properties with models for evolution in a cloudy ISM as well as for characteristics of remnants which have entered the radiative phase of evolution.

28.06

EGRET Observations of Gamma-Ray Emission from Supernova Remnants

J.A. Esposito, P. Sreekumar (USRA, NASA/GSFC), S.D. Hunter (NASA/GSFC), G. Kanbach (MPE)

We have continued our analysis of data from EGRET observations of supernova remnants near the Galactic plane (Esposito *et al.* 1996). The integral intensities or upperlimits have been determined, and spectra fitted when statistically justified. We have included cycle 4 data for some sources (e.g. IC443 and Monoceros). We will present our gamma-ray results and an interpretation based upon Galactic cosmic ray shock acceleration by supernova remnants.

Esposito, J. A., Hunter, S. D., Kanbach, G. and Sreekumar, P. 20 April 1996, ApJ, in press

Session 29: Invited Talks
Invited Session, 4:00-5:30pm
96/06/10, Union Theater

29.01

First Helioseismic Results from the Global Oscillation Network Group

Juri Toomre (JILA, University of Colorado)

Helioseismology studies the internal structure and dynamics of the sun, utilizing very precise measurements of the frequencies of sound waves that propagate throughout the solar interior and are observed at the surface. Efforts to accurately and precisely measure the mode frequencies from a single observing site have met with fundamental limitations imposed by the inevitable interruptions arising from the day-night cycle. To address such problems, the NSF-sponsored Global Oscillation Network Group (GONG) project has developed a network of six identical instruments around the world providing velocity images nearly continuously, a data processing system that can keep up with the massive data flow, and is supported by a vigorous scientific community structured around GONG teams that have shared in all aspects of the development of the project. Though the primary helioseismic data deals with the frequencies and their splittings for the nearly half-million global acoustic modes detectable with the GONG instruments, the data also allows study of how wave fields are locally influenced by flows and magnetic structures below the solar surface, and further provides direct measures of larger-scale flows at the surface.

We shall briefly describe the network, instruments, and data analysis, and then review some of the preliminary scientific results obtained by the teams through inversion of the frequency data, dealing with the structure of the solar interior and the physics of stellar models, and an assessment of the differential rotation profile with depth and latitude. Early results will also be presented concerning nearly steady surface flows of the solar surface.

MONDAY

Asca Observation of a Crab-like supernova remnant 3C58

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We present the Asca results of a Crab-like supernova remnant 3C58. We analyzed the data from two points of view. One is the spatially resolved energy spectral analysis by using the SIS data. Although the integrated spectrum over the whole nebula is consistent with the previous results, we have found for the first time that the spectrum is harder in the central part and gets softer toward the periphery. The power-law index at the periphery is steeper than that of the central part as much as about 0.4. Correspondingly, the nebular size decreases with increasing photon energy. Comparison with the theoretical models shows that the energy density has to be dominated by the particles rather than by the magnetic field at the injection, as is the case for the Crab. The other is the timing analysis by using the GIS data. As we have not found a significant pulsation, we present the upper limit of the pulsed fraction.

1. Introduction

3C58 is a Crab-like supernova remnant, and believed to be a remnant of a historical event in A.D. 1181. It shows a center-filled structure both in the radio [8] and in the X-ray wavelength [2, 4]. The X-ray energy spectrum has been known to show a power-law type with a photon index $\sim$2.2 [1]. There exists an X-ray point source in the midst of the nebula, whereas it is radio quiet.

2. Analysis and Results

We have analyzed the X-ray energy spectrum of the whole nebula and confirmed the previous results that the spectrum is a power-law type with the photon index 2.2$\sim$2.3 and the absorption column $3.5\sim4\times10^{21}[\mathrm{cm}^{-2}]$. The ASCA result is shown in figure 1a as a multi-frequency spectrum together with the flux density in other wavelengths. The Crab spectrum is also shown by a broken line for comparison. As noted by Green (1994), the spectral break occurs at around 5×10^{10}Hz in 3C58, which is much lower than the Crab value of about 10^{13}Hz. Considering the high radio/X-ray luminosity ratio, injection rate may have decreased appreciably from the initial value.

To examine the spatial distribution of the energy spectra, we extracted the spectra from concentric annular regions and found that the spectrum was the hardest at the center and got softer toward the periphery. For the further investigation of this trend, we extracted images in four different energy ranges and fitted them with a model function convolved by an XRT (X-ray telescope) PSF (point spread function). We employ a two dimensional Gaussian plus a

constant to fit the nebular emission and the background.

$$f(x,y) = A \cdot \exp(-(x'-x_0)^2/2\sigma_x^2 - (y'-y_0)^2/2\sigma_y^2) + B \quad (1)$$

where free parameters are A, B, x_0, y_0, σ_x, σ_y and θ. x' and y' are measured along the major and minor axes of the nebula respectively, and related to the equatorial coordinate, x and y, by rotating angle of θ. In fact, θ is almost zero, since the object is elongated in the east-west direction parallel to the coordinate.

The utilized PSFs are calculated based on the function developed by Dr. Awaki, which takes into account the positional and energy dependences of the source. To estimate the systematic error of the PSFs, we utilized raw images of a point source, 3C273, for comparison. We found that the systematic error dominates the statistical errors. Typical systematic error in the determination of σ_x and σ_y is found to be ~20%. The results are shown in figure 1b.

We did find that the nebular size decreased with increasing photon energy. A similar trend has been established for the Crab nebula [6, 7]. Semi-quantitative comparison with the theoretical model [5] shows that the energy density has to be dominated by particles rather than by the magnetic field at the injection point.

We have performed power spectral analyses on a part of the GIS data. Photons within 2 arcminutes around the point source were analyzed and the upper limit of the pulsed fraction was obtained to be ~ 8% in the frequency range 1-16[Hz]. Assuming that the energy spectrum of the putative pulsar to be Crab-like and that the 7% of the total flux come from the point source [4], the upper limit of the pulsed fraction of the point source is obtained to be ~ 60%.

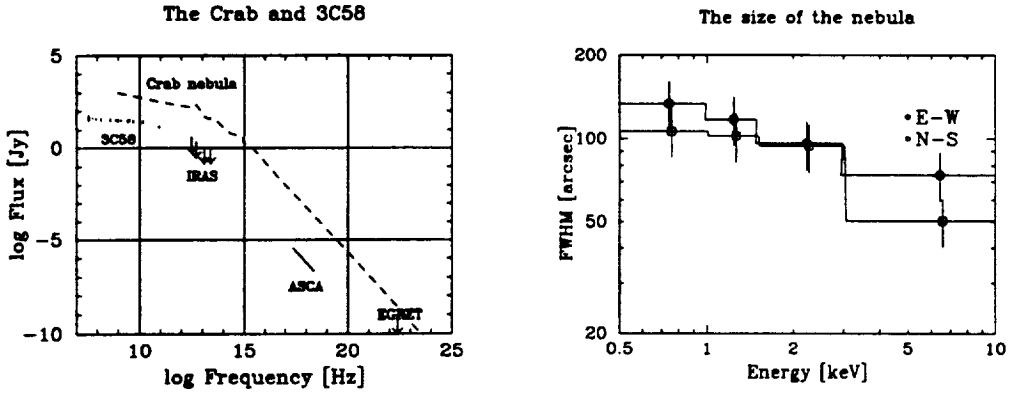

Fig. 1. a) Multi-frequency spectra of 3C58 and that of the Crab nebula. b) The size of the nebula as a function of energy range. Error bars show typical systematic errors (1σ).

3. References

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